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ABSTRACT

It has been hypothesized that letters in orthographic strings (those that follow the rules of English) are more accurately identified than letters in nonorthographic strings because confusions about the positions of letters are more likely in nonorthographic strings. This hypothesis was tested by giving 16 college students a set of targets, one of which appeared in each three-letter string, and having subjects report the position of the target as well as its identity after each exposure. One-half of the subjects reported the position first. Thirty-two trigrams, one-half of which were orthographic, were each shown once per block in five different test blocks given to each of the subjects. The target was the first or last letter in each trigram. Performance was found to be much better on orthographic strings than on nonorthographic strings, and most of the difference occurred when the position of the target letter was reported correctly. When the position was misreported, identity errors still were slightly more frequent in nonorthographic strings. The results suggest that position errors are not a strong determinant of the word-superiority effect. (NB)

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Is the Word-superiority Effect in Target Search Tasks Based on Perceptual Confusions?

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Predesignated target letters are more accurately identified in orthographic (e.g. word) strings than in nonorthographic ones. The current experiment was run to determine whether this effect occurs because subjects are more likely to process a letter in a nontarget position as the target in nonorthographic strings. Subjects reported not only the target letter but also its position in the string. Accuracy differences with the two string types were most apparent when target position was reported correctly.

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If subjects are required to search each of a number of briefly presented letter strings for predesignated targets, accuracy will be higher on orthographic strings (those that follow the rules of English) than on nonorthographic ones. Paap and Newsome (1980) have argued that this word-superiority effect (WSE) occurs because subjects are more likely to become confused about which position in the string contains the target letter in nonorthographic strings. For example, suppose that the target set is M, N, P, and R, and the string MICK is presented. The subject may feel somewhat confident that the first three positions contained M, I, and C, but be less certain of whether the fourth position contained a K or an R. Goldiamond and Hawkins (1958) found that even in the complete absence of visual information, subjects are biased toward guessing letters that form words (orthographic strings). Since MICR is not orthographic, the first position will be correctly selected as

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containing the target, and the response of M will be correct. However, suppose the string MJCK had been presented, and the subject is fairly confident about the identity of the first three letters but unsure about whether fourth position contained a K or an R. Since neither K nor R makes the string orthographic, the choice between M in the first position and R in the fourth will be less likely to result in the correct response than when the orthographic string MICK is presented.

One way to test Paap and Newsome's perceptual-confusion explanation of the WSE might be to require subjects to report the position of the target in each string as well as its identity. If perceptual confusions are responsible for the WSE, poorer performance with nonorthographic strings should be observed primarily when the target's position is misdesignated.

Method

Subjects

Sixteen subjects served for extra credit in a General Psychology course. All reported normal or corrected-to-normal acuity.

Apparatus

Stimuli were shown in a Scientific Prototype, Model N-1000, three-channel manual tachistoscope, which was equipped with a microswitch to allow subjects to initiate exposures. The luminance of both the stimulus and fixation/masking channels was 65.0 cd/m^2, as measured with a Spectra Lumicon photometer with Photospot attachment.

Stimuli

Stimuli were prepared with a Berol RapiDesign lettering guide, No. 2960, by tracing letters onto white index cards in black ink from a Pilot Razor Point pen. Stimuli are shown in the appendix. The CVC strings were all orthographic, with each nonorthographic string produced by transposing the nontarget letters in the corresponding orthographic string. The targets (M, N, P, and R) appeared equally often in either the first or last position of each string type. A pattern mask of three superimposed X's and O's was traced from the same lettering guide and in the same manner as the stimulus strings. A small black fixation dot, .05 deg in diameter, was placed .1 deg below the middle character of the masking string. Each stimulus string and the masking string subtended a visual angle of approximately .30 deg vertically and .76 deg horizontally. Cards were taped to Masonite slides for manual insertion into the tachistoscope, with alignment such that the letters in each string would appear in the same location as the corresponding characters in the mask if both were shown simultaneously.

Experimental Design

Each subject received six blocks of 32 exposures per block. Within each block all trigrams were exposed once each in a random order. Half of the subjects made the position judgment before the target identity judgment. The first block was used for practice and duration-setting, and was not analyzed.

Procedure

Each subject was told to initiate each exposure at any time after a .2 s tone from the tachistoscope sounded as a ready signal for each trial. The exposure duration was lowered from an initial setting of 200 ms at the beginning of the first block to stabilize at approximately 70% on the identification responses by the first test trial. Thereafter the exposure duration was changed only between blocks when necessary to maintain that level of accuracy. After each exposure the subject gave both judgments (position and identity) aloud. Trials proceeded in an uninterrupted sequence, and no feedback regarding accuracy was given any subject.

Results

In the initial analysis of the data, the order in which the position and identity judgments were made was included as a between-subjects variable, but there was no significant main effect or interaction associated with it. Targets were identified much more accurately in the orthographic strings, $F(1, 14) = 44.75$, with 75.5% of identifications correct in those strings but only 63.8% correct in the nonorthographic strings. There was no significant difference in the accuracy with which the target position was designated in the two types of strings, with 22.8% and 20.5% of the presentations resulting in position errors for the orthographic and nonorthographic strings, respectively.

A second analysis of the data compared the proportion of presentations resulting in a position error, an identification

Table 1

Proportion of Presentations of Orthographic and Nonorthographic Strings Involved in Correct and Incorrect Reports of Position (P/$\bar{P}$) and Identity (I/$\bar{I}$)

	Report		
String Type	P & $\bar{I}$	$\bar{P}$ & I	$\bar{P}$ & $\bar{I}$
Orthographic	.140	.100	.105
Nonorthographic	.227	.093	.135

error, or both, for the orthographic and nonorthographic strings. The results appear in Table 1. Analysis of variance showed that the proportions differed for the two string types, $F(2, 30) = 16.01$, $p < .001$. An orthogonal comparison indicated that most of this difference came from the trials upon which the target was misidentified but its position was designated correctly, $F(1, 30) = 26.96$, $p < .001$. However, the other permissible orthogonal comparison showed a weak interaction between string type and correct versus incorrect identification reports when the target position was misdesignated, $F(1, 30) = 5.05$, $p < .05$. The results of an independent t test suggest that the interaction was due to the difference in identification accuracy between the two string types when the position was misdesignated, $t(15) = 2.40$, $p < .05$.

Discussion

Target identification was much more likely to be correct in orthographic strings, although there was no overall difference in

accuracy of designating the target position in orthographic and nonorthographic strings. The mean proportion of position responses in error for the two string types actually is in the opposite direction from that predicted by the perceptual confusion explanation. Also contrary to the perceptual-confusion explanation is the fact that most of the difference in identification performance between the two string types occurred when the target's position was reported correctly.

The weak interaction from the orthogonal comparison showed that when target position was misreported, identification was more likely to be incorrect than correct, but differentially so with orthographic and nonorthographic strings. The results of a *t* test suggested that the interaction was likely due to differences in identity errors between string types, although admittedly the test was not very conservative. The interaction somewhat weakens the case that the data make against the perceptual-confusion explanation of the WSE. There is, of course, no reason why analyzing the wrong letter as the target would result in more correct identifications in orthographic strings than in nonorthographic ones. In fact, identification accuracy should be no better than chance in this situation no matter which string type was presented; therefore identification errors should be three times as frequent as identification successes (ignoring a chance baseline from correct guessing). However, the data clearly show that incorrect identifications were only slightly more frequent than correct ones when the target position was misreported.

Subjects therefore were not consistently accurate in their designation of which letter they identified as the target. As Brian Butler, among others, has argued, identifying and localizing targets may be at least partly independent operations (Butler, 1980, 1981). Even though the WSE was most apparent by far when the target position was correctly designated, we must nevertheless interpret our results as merely suggesting that the WSE occurs primarily when the correct letter is processed as the target.

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Appendix

Identification Errors When Target Position Was Misdesignated (M) and Correctly Designated (D) for Each Trigram

Orthographic			Nonorthographic		
Trigram	M	C	Trigram	M	C
MED	13	10	MDE	11	19
NED	10	13	NDE	13	18
PED	3	9	PDE	2	16
RED	3	5	RDE	3	16
MAG	14	11	MGA	14	22
NAG	2	16	NGA	9	19
PAG	1	10	PGA	8	17
RAG	4	10	RGA	6	25
HEM	4	19	EHM	13	15
HEN	16	12	EHN	14	25
HEP	9	7	EHP	11	12
HER	10	14	EHR	13	22
BUM	19	14	UBM	20	8
BUN	18	10	UBN	11	24
BUP	4	5	UBP	12	11
BUR	5	12	UBR	13	21
Totals	135	177		173	290